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SUBMISSION IN RESPONSE TO

ROYAL COMMISSION INTO THE NUCLEAR FUEL CYCLE

ISSUES PAPER 3

"ELECTRICITY GENERATION"

July 2015

INTRODUCTION

Friends of the Earth Adelaide opposes electricity generation using nuclear fuels on broad health, safety, environmental and economic grounds. Nuclear power is not economically viable and poses unacceptable risks. Nuclear power generation is inevitably and inextricably linked to nuclear weapons proliferation, and is also vulnerable to terrorism.

Any new power stations in Australia should use renewable energy technology which is safer, cheaper and more environmentally friendly than nuclear power generation and does not have weapons proliferation or terrorism implications.

Any analysis of the feasibility of generating electricity from nuclear fuel should examine critically the track record of the international nuclear industry, rather than accept at face value the rosy predictions based on wishful thinking by pro-nuclear advocates making promises about technologies that have not been commercially realised. The nuclear industry has a long and checkered track record and for a mature industry of this nature the past is the best predictor of the future.

A comprehensive and credible analysis of the economic unviability of the nuclear power industry in the USA (2011 report from the Union of Concerned Scientists "Nuclear Power: Still Not Viable Without Subsidies"[1]) is included as Appendix 1.

This submission addresses the following sections of Issues Paper 3 "Electricity Generation:
3.1 (suitable areas)
3.2 (connection to NEM)
3.3 (off-grid)
3.6 (lessons from case studies)
3.7 (electricity generation market)
3.9 (lessons from accidents)
3.10 (regulation)
3.11 (greenhouse gases)
3.12 (waste)
3.13 (health & safety)
3.14 (safeguards needed)
3.15 (effect on electricity market)
3.16 (unit costs of other electricity sources)
3.17 (impacts on other sectors of the economy)

The issues paper presupposes that the objective is to generate electricity from nuclear energy. We reject this premise and believe the way the questions are formulated biases the inquiry. We therefore respond as much to the underlying assumptions behind the questions as to the questions themselves.

3.1 Are there suitable areas in South Australia for the establishment of a nuclear reactor for generating electricity? What is the basis for that assessment?

There are no suitable areas in Australia for the establishment of a nuclear reactor for generating electricity. When considering the risks to the safety of the population, evacuations zones, risks to the environment and the amount of water needed, terrorism and weapons proliferation risks, it is clear that nuclear power is no solution to the perceived demand for energy.

Nuclear power is not safe and is not wanted by the Australian people, as demonstrated by its prohibition in both the *Environment Protection and Biodiversity Conservation Act 1999* Act and the *Australian Radiation Protection and Nuclear Safety Act 1998.*

Environment Protection and Biodiversity Conservation Act 1999
Section 140A No approval for certain nuclear installations
The Minister must not approve an action consisting of or involving the construction or operation of any of the following nuclear installations:
(a) a nuclear fuel fabrication plant;
(b) a nuclear power plant;
(c) an enrichment plant;
(d) a reprocessing facility.

Australian Radiation Protection and Nuclear Safety Act 1998
Section 10 Prohibition on certain nuclear installations

1. *Nothing in this Act is to be taken to authorise the construction or operation of any of the following nuclear installations:*
   (a) a nuclear fuel fabrication plant;
   (b) a nuclear power plant;
   (c) an enrichment plant;
   (d) a reprocessing facility.

Note that the National Policy of the Australian Labor Party prohibits the installation of a nuclear power plant.[2]

NUCLEAR POWER UNWANTED IN AUSTRALIA

A 2012 nation-wide survey was performed in Australia following the disaster at the Fukushima Daiichi Nuclear Power Station in Japan, an event triggered by the 11 March 2011 Tohoku earthquake and tsunami. A majority of Australian respondents had an unfavourable attitude to nuclear power (50.1% unfavourable compared to 26.9% favourable) and most of those were *not* willing to accept nuclear power as an option, even if it helped tackle climate change. The most popular option was expanding the use of renewable energy sources (71%) followed by energy-efficient technologies (58%) and behavioural change (54%). The people who conducted the survey concluded, *"Opposition to nuclear power will continue to be an obstacle against its future development"*[3]. This conclusion is consistent with the results of a recent Advertiser survey which found that only 26% of South Australians would support a nuclear power station in the state.[4] Strong opposition to nuclear power is long standing[5] and these recent surveys demonstrate that there is no reason to assume that Australians are about to become favourable any time soon.

3.2 Are there commercial reactor technologies (or emerging technologies which may be commercially available in the next two decades) that can be installed and connected to the NEM? If so, what are those technologies, and what are the characteristics that make them technically suitable? What are the characteristics of the NEM that determine the suitability of a reactor for connection?

Current commercially available reactors have a capacity of 1,000 MW or larger. Reactors of this size operating at full capacity would represent more than two-thirds of South Australia's "native consumption" for 2013-2014,[6] and consumption, especially in the NEM, is predicted to continue its downward trend over the next 10 years. In fact, the capacity of a single such reactor would be more than 200 MW greater than South Australia's minimum operational demand for 2014-2015 of 790 MW.[7]

Given the fact that nuclear reactors do not respond flexibly to demand fluctuations, this would put a huge strain on the grid. South Australia is connected to the National Electricity Market (NEM), so the surplus could theoretically be exported to the Eastern States (at the expense of greater transmission losses than if the electricity could be used locally), but given that the Australian Energy Market Operator (AEMO) is already concerned about the "potential impacts of lowered operational minimum demand"[8] due to the high uptake of rooftop solar in South Australia, clearly there is no room for a reactor of this size. One certain impact of any decision to construct such a reactor would be a dramatic reduction in construction of renewable energy power stations. It would also be expected that any such decision would be accompanied by measures to restrict the uptake of rooftop solar. This might suit the agenda of some anti-renewable energy interests, but it would not reflect the will of the South Australian public and would destroy an industry with high job-creating potential.

Nuclear proponents in Australia claim that Generation IV (Gen 4) reactors or small modular reactors (SMR) are a viable alternative to current commercially available reactors. These claims ignore some critical problems.

First, they overlook the fact that although these reactors have been on the drawing boards for a long time (some going back to the beginnings of the nuclear power age), there are still none in commercial operation. France's Institute for Radiological Protection and Nuclear Safety (IRSN) published a report in April this year which provides a realistic assessment of the potential of Gen 4 reactors and so-called advanced fuel cycle technologies. In regard to molten salt reactors, one of the unproven technologies favoured by nuclear proponents in Australia, it makes the following comment:

> *"[T]he feasibility of the concept and the associated reprocessing has not yet been established. This is particularly significant given that some very specific problems are associated with the concept (containment of liquid fuel, choice of materials, corrosion by the molten salts, reprocessing of the salt, processing of the ultimate used salts, etc.). It therefore seems that these prospective technologies, which represent a complete break with the current technologies, will probably not be accessible until at least the second half of this century given the major developments and technological breakthroughs needed" (IRSN 2015, p. 209).*[9]

The web site on which the report is published is pessimistic about the prospects of the advanced fuel cycle technologies under consideration. It states:

> *"On the basis of its examination, IRSN considers the SFR system to be the only one of the various nuclear systems considered by GIF to have reached a degree of maturity compatible with the construction of a Generation IV reactor prototype during the first half of the 21st century; such a realization, however, requires the completion of studies and technological developments mostly already identified"(IRSN 2015 press release).*[9]

In regard to the SFR system (sodium cooled fast reactor)—the only one said to have any short- to medium-term prospects—it is important to remember that commercialisation of this type of reactor has been claimed to be just around the corner since the 1960s, but has receded like a mirage ever since. The USA, the UK, Germany, France and Japan have all had SFR programs that turned out to be costly failures.[10] In the case of Japan, nuclear policy makers originally proposed commercialising SFRs by about 1980,[11] but that target receded further and further into the future, until by 2005 the target for commercialization had slipped to 2050.[12] Predictions of early commercialisation of SFRs should, therefore, be taken with a large grain of salt.

Some point to Russia, China and India, but there is limited data available on their programs. It is known that Russia's fast breeder reactor program has been plagued by sodium leaks and fires. *'Russia's BN-600 has experienced a respectable capacity factor but only because of the willingness of its operators to continue to operate it despite multiple sodium fires'.*[13]

The Fukushima nuclear accident is testimony to the dangers of cutting corners on safety, and the Soviet Union experienced disasters of its own. In any case, in the current diplomatic climate it is inconceivable that Australia would turn to Russia for sensitive technology of this nature.

A second critical problem relates to SMRs. While SMRs are promoted as ready to go and addressing the scale problem discussed at the beginning of this section, so far no one has been willing to buy one for commercial operation.[14] A major reason for this is that they are regarded as too expensive and too risky. Proponents argue that costs will come down with mass production, but if no one is willing to invest in the assembly line, any (possibly illusory) economies of scale will not eventuate.

Clearly South Australia (or even the whole of Australia) alone cannot provide the demand to sustain mass production, but if it decides to become a lead customer, it will not benefit from these alleged economies of scale, because the assembly line will not be in place. Furthermore, economies of scale would not be available for the regulatory system unless large numbers were constructed in Australia. Even then, each installation would have to undergo proper regulatory checking, so it is possible that more smaller plants could incur more regulatory costs than smaller numbers of larger plants. Hence, even if a case could be made for them in theory, the business case must wait for the mass production assembly line to be up and running. At this stage, there is no evidence that such an assembly line will be in place any time soon.

It is impossible to reliably speculate about technologies that may be commercially available in two decades time, except to note that the industry's track record of delays, cost over-runs, and unfulfilled promises suggests a sceptical attitude is warranted. The optimistic predictions in circulation are not based on facts and evidence.

3.3 Are there commercial reactor technologies (or emerging technologies which may be commercially available in the next two decades) that can be installed and connected in an off-grid setting? If so, what are those technologies, and what are the characteristics that make them technically suitable? What are the characteristics of any particular off-grid setting that determine the suitability of a reactor for connection?

Commercially available reactors are too big for off-grid settings and no small reactor technologies have been commercially tested. For South Australia to become a lead customer for such a reactor would be prohibitively expensive and extremely risky. (See section 3.2 for a discussion of why this option would be so expensive.)

3.6 What are the specific models and case studies that demonstrate the best practice for the establishment and operation of new facilities for the generation of electricity from nuclear fuels? What are the less successful examples? Where have they been implemented in practice? What relevant lessons can be drawn from them if such facilities were established in South Australia?

Best practice for the establishment and operation of nuclear electricity generation has not proved adequate in practice on health, safety, environmental and economic grounds. Disastrous examples include Windscale (UK), Three Mile Island (USA), Chernobyl (Ukraine) and Fukushima (Japan) (refer to section 3.9).

Nuclear power is financially unviable and cannot exist without massive taxpayer subsidies (see below). Risks are uninsurable, as no commercial insurance company will expose itself to potential financial ruin. As a result, governments have been forced to limit the insurance cover required of nuclear power plant operators and to cover the excess themselves (refer section 3.16). Hence, taxpayers end up picking up the enormous tab when accidents inevitably occur. Refer to the following quote by Japanese environment economics professor Kenichi Oshima, who has performed an in depth study[15] of the economics of the Fukushima disaster:

"The costs for the accident are designed to be borne by the people through taxes and utility bills."

NUCLEAR SUBSIDIES IN THE USA

A major 2011 US report from the Union of Concerned Scientists ***"Nuclear Power: Still Not Viable Without Subsidies"***[1] (entire report presented in Appendix 1) states:

"Conspicuously absent from industry press releases and briefing memos touting nuclear power's potential as a solution to global warming is any mention of the industry's ***long and expensive history of taxpayer subsidies and excessive charges to utility ratepayers****. These subsidies not only enabled the nation's existing reactors to be built in the first place, but have also supported their operation for decades."*

"The industry and its allies are now pressuring all levels of government for ***large new subsidies*** *to support the construction and operation of a new generation of reactors and fuel-cycle facilities. The substantial political support the industry has attracted thus far rests largely on an uncritical acceptance of the industry's economic claims and an incomplete understanding of the subsidies that made—and continue to make—the existing nuclear fleet possible. Such blind acceptance is an unwarranted, expensive leap of faith that could set back more cost-effective efforts to combat climate change".*

Historic subsidies of the nuclear industry in the USA are *"estimated to exceed US seven cents per kilowatt-hour (¢/kWh)—an amount equal to about 140% of the average wholesale price of power from 1960 to 2008, making the subsidies more valuable than the power produced by nuclear plants over that period."*[1]

FUKUSHIMA COSTS AND SUBSIDIES

Japanese researchers estimate that responding to the tragedy at the Fukushima nuclear plant will cost $US105 billion, twice as much as the government predicted at the end of 2011.[15] The expenses are for radiation clean-up and compensation to residents; and costs are sure to rise again before the disaster is fully dealt with in 30-40 years' time. The projected expenses include $US47 billion for compensation to residents in the affected area of the crippled nuclear plant, $US23 billion for the radiation clean-up of the territories, $US20.1 billion to scrap the disaster-hit plant and $US92.7 million for the temporal storage of radioactive soil. The research was led by Kenichi Oshima, environment economics professor at Ritsumeikan University, and Masafumi Yokemoto, professor of environment policy at Osaka City University, with the costs calculated based on data released by the Tokyo Electric Power Company (TEPCO). Other researchers have estimated that the costs of the accident will reach $US166 billion.[16] Of course, these are just the financial costs. They by no means fully address the suffering of the victims of the accident. The cost in terms of the upheaval of lives, loss of land handed down for generations, and the breakup of families and communities cannot be quantified in financial terms.

UK SUBSIDIES

The UK's nuclear industry was originally subsidised by being part of a nuclear weapons program. Now, as the UK moves towards constructing its first new nuclear power plant in 20 years, it has decided to subsidise the plant through a 'contract for difference' arrangement. The government's decision would represent a guaranteed 'strike price' for the Hinkley Point C plant of GBP 92.50/MWh for 35 years,[17] a far longer period than the strike price for renewable energy technologies. According to Greenpeace UK's John Sauven:

"It will lock a generation of consumers into higher energy bills, via a strike price that's expected to be double the current price of electricity, and it will distort energy policy by displacing newer, cleaner, cheaper technologies".[18]

In response to this massive subsidy, the Austrian Government has filed a lawsuit with the European Court of Justice. The Austrian Chancellor Werner Faymann said nuclear power *"is not an innovative technology and is therefore not worthy of subsidy"*.[19]

3.7 What place is there in the generation market, if any, for electricity generated from nuclear fuels to play in the medium or long term? Why? What is the basis for that prediction including the relevant demand scenarios?

The arguments in section 3.2—including the problems of scale for commercially available reactors, the non-existence of commercial smaller reactors, and falling electricity demand—apply equally to this question. These factors alone make nuclear energy unviable for South Australia.

Even if it were feasible to build nuclear power plants, it is important to understand the devastating effect this would have on the renewable energy sector, which has grown markedly in South Australia in recent years. In 2013-2014 the combined capacity of wind and rooftop solar represented 37% of electricity generated in South Australia[20] and, despite recent job losses due to the Abbott Government's attacks on renewable energy, employment in the sector has grown nationally by 44% since 2009-10.[21,22] Nuclear energy, as a capital intensive technology, creates fewer jobs per dollar than renewable energy[23] and is inflexible to changes in electricity demand. It is, in fact, a direct competitor to renewable energy and an enemy of energy efficiency.[24]

Once the reactors have been built, the most economical way to operate them from the perspective of their owners is to operate them at as high a capacity factor as possible. Nuclear proponents try to make a virtue of necessity by calling this 'baseload', but in fact it means nuclear generation is prioritised over all other energy sources. Renewables are squeezed out and efforts to reduce demand are resisted. This pattern is exemplified by the debacle over Japan's energy policy. Since the December 2012 change of government, the nuclear industry has regained control and has been resisting the uptake of renewable energy and the liberalisation of the electric power system, as it has done ever since the 1990s (see, for example, Ueda 2015).[25]

There are flexible energy sources which do complement variable output types of renewable energy, but nuclear energy is not one of them. For example, natural gas, whose cost structure and dispatchability make it a perfect fit with high penetrations of renewable energy. Of course, natural gas is a problem from the perspective of greenhouse gas emissions, but increasingly renewable energy sources, especially when distributed over a broad area and combined with demand management, are able to provide flexible response to fluctuations in supply from variable renewable resources[26,27].

A recent report commissioned by the Conservation Council of South Australia argues that South Australia could be powered by 100% renewable energy in just 15 years.[27] According to the report, written by Mark Diesendorf of the University of NSW:

"reliability is achieved by:

- *a mix of variable RE (e.g. wind and solar PV) and flexible, dispatchable RE sources (e.g. CST with thermal storage, biofuelled gas turbines and hydro with dams);*
- *geographic dispersion of RE power stations assisted by one or two new major transmission links;*
- *demand management assisted by 'smart' meters and 'smart' switches in a 'smart' grid."* (p. 6)

Even if it were viable to choose nuclear energy (which we have argued above that it is not), to do so would prevent South Australia, with its abundance of renewable energy resources, from building on its position as a world leader in renewable energy. It would condemn South Australia to high cost, high risk (from both an economic and safety perspective) energy, and a legacy of nuclear waste that will remain toxic for hundreds of thousands of years.

3.9 What are the lessons to be learned from accidents, such as that at Fukushima, in relation to the possible establishment of any proposed nuclear facility to generate electricity in South Australia? Have those demonstrated risks and other known safety risks associated with the operation of nuclear plants been addressed? How and by what means? What are the processes that would need to be undertaken to build confidence in the community generally, or specific communities, in the design, establishment and operation of such facilities?

PUBLIC PERCEPTION

Friends of the Earth Adelaide is concerned about the biased wording of the last of these questions. It presupposes that the objective is to construct and operate nuclear reactors and that the public needs to be educated to accept them. This is characteristic of the nuclear industry's 'deficit model' approach to the public, where ordinary citizens are seen as ignorant and lacking a 'correct understanding'. If the Fukushima nuclear accident taught us anything, it taught us the folly of governments and industry making up their minds in advance and conducting campaigns to gain 'public acceptance' for a predetermined outcome.[28]

Section 3.1 references legislation and surveys showing the Australian public do not want nuclear power and do not believe it can be made safe. This opposition should not be treated as an obstacle to be overcome, but as reflecting genuine concerns about the health, safety and environmental risks of nuclear power and the danger of nuclear proliferation. History and science show that these concerns are well founded, as discussed in this section and elsewhere in this submission.

NUCLEAR ACCIDENTS

Accurate data and statistics on nuclear accidents are difficult to obtain as the International Atomic Energy Agency does not keep a full historical database. This is a glaring omission.[29]

Also, nuclear power plant operators are reticent about reporting incidents and accidents. This was particularly true in the first few decades of nuclear power, but the Fukushima accident demonstrates that timely disclosure of information continues to be a problem. Clearly, it is impossible to make full and proper decisions on data that has not been gathered or published.

The chronological accident data in Table 1 was collated by *The Guardian* newspaper, but it is by no means complete.[30] Furthermore, the INES scale on which the data is based is an arbitrary tool: each country self-reports and the level is not assessed independently. Nevertheless, it shows that nuclear accidents and incidents that could potentially lead to accidents with serious consequences are not rare. The list also includes some little known, but serious accidents in the early days of nuclear power. Details of these accidents were covered up at the time.[31]

Note: International Nuclear Events Scale levels 1–3 are called "incidents" and levels 4–7 "accidents". Each level of the scale indicates that an event is 10 times more severe than the level below it with INES Level 7 the most severe (eg Chernobyl and Fukushima).

TABLE 1 NUCLEAR POWER STATION ACCIDENTS AND INCIDENTS 1952-2011				
Year	**Incident**	**INES level**	**Country**	**IAEA description**
2011	Fukushima	7	Japan	Reactor shutdown after the 2011 Sendai earthquake and tsunami; failure of emergency cooling caused an explosion. All three reactor cores melted in the first 3 days.
2011	Onagawa		Japan	Reactor shutdown after the 2011 Sendai earthquake and tsunami caused a fire
2006	Fleurus	4	Belgium	Severe health effects for a worker at a commercial irradiation facility as a result of high doses of radiation
2006	Forsmark	2	Sweden	Degraded safety functions for common cause failure in the emergency power supply system at nuclear power plant
2006	Erwin		US	Thirty-five litres of a highly enriched uranium solution leaked during transfer
2005	Sellafield	3	UK	Release of large quantity of radioactive material, contained within the installation
2005	Atucha	2	Argentina	Overexposure of a worker at a power reactor exceeding the annual limit
2005	Braidwood		US	Nuclear material leak
2003	Paks	3	Hungary	Partially spent fuel rods undergoing cleaning in a tank of heavy water ruptured and spilled fuel pellets
1999	Tokaimura	4	Japan	Fatal overexposures of workers following a criticality event at a nuclear facility
1999	Yanangio	3	Peru	Incident with radiography source resulting in severe radiation burns
1999	Ikitelli	3	Turkey	Loss of a highly radioactive Co-60 source
1999	Ishikawa	2	Japan	Control rod malfunction
1993	Tomsk	4	Russia	Pressure buildup led to an explosive mechanical failure
1993	Cadarache	2	France	Spread of contamination to an area not expected by design
1989	Vandellos	3	Spain	Near accident caused by fire resulting in loss of safety systems at the nuclear power station
1989	Greifswald		Germany	Excessive heating which damaged ten fuel rods
1986	Chernobyl	7	Ukraine (USSR)	Widespread health and environmental effects. External release of a significant fraction of reactor core inventory
1986	Hamm-Uentrop		Germany	Spherical fuel pebble became lodged in the pipe used to deliver fuel elements to the reactor
1981	Tsuruga	2	Japan	More than 100 workers were exposed to doses of up to 155 millirem per day radiation
1980	Saint Laurent des Eaux	4	France	Melting of one channel of fuel in the reactor with no release outside the site
1979	Three Mile Island	5	US	Severe damage to the reactor core
1977	Jaslovské Bohunice	4	Czechoslovakia	Damaged fuel integrity, extensive corrosion damage of fuel cladding and release of radioactivity
1969	Lucens		Switzerland	Total loss of coolant led to a power excursion and explosion of experimental reactor
1967	Chapelcross		UK	Graphite debris partially blocked a fuel channel causing a fuel element to melt and catch fire

1966	Monroe		US	Sodium cooling system malfunction
1964	Charlestown		US	Error by a worker at a United Nuclear Corporation fuel facility led to an accidental criticality
1959	Santa Susana Field Laboratory		US	Partial core meltdown
1958	Chalk River		Canada	Due to inadequate cooling a damaged uranium fuel rod caught fire and was torn in two
1958	Vinča		Yugoslavia	During a subcritical counting experiment a power buildup went undetected - six scientists received high doses
1957	Kyshtym	6	Russia	Significant release of radioactive material to the environment from explosion of a high activity waste tank.
1957	Windscale Pile	5	UK	Release of radioactive material to the environment following a fire in a reactor core
1952	Chalk River	5	Canada	A reactor shutoff rod failure, combined with several operator errors, led to a major power excursion of more than double the reactor's rated output at AECL's NRX reactor

The summary below of three major nuclear accidents (Fukushima, Chernobyl, and Three Mile Island) draws out some characteristic failings of the nuclear industry: an unwarranted belief in the myth of nuclear safety, captive nuclear regulators, a lack of adequate emergency response measures, prioritisation of profits over safety, and a tendency to trivialise the suffering of the victims. To a significant degree, these characteristics are inevitable wherever nuclear power is introduced. The massive financial investment places owners and operators of nuclear power plants under tremendous pressure to keep the reactors running, even if safety is compromised. At the same time, nuclear power programs cannot succeed without the full backing of the government, and the economic and political power of companies with the resources to invest in nuclear power tend to lead to cosy relationships between the government and industry. This is especially so at the local and regional levels, where the owner of a nuclear power plant is invariably a dominant economic presence, as would be the case in a relatively small economy like South Australia. It is, therefore, unrealistic to expect that the safety-first slogan will be honoured in practice.

FUKUSHIMA – JAPAN 2011- ongoing
INES LEVEL 7: *“Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures”*

The operating reactors at Tokyo Electric Power Company’s (TEPCO) Fukushima Daiichi Nuclear Power Station all shut down after the 11 March 2011 Sendai earthquake and tsunami, but failure of emergency cooling caused the reactor cores of units 1, 2 and 3 to melt down in the first three days. By sheer good luck, the spent nuclear fuel in the unit 4 spent fuel pool did not melt down too.[32] Hydrogen explosions exacerbated the release of radiation, but here too good fortune intervened in the form of prevailing winds that carried most of the radioactivity away from the population and out to the Pacific Ocean.

Underlying causes of the accident included the failure of TEPCO to take adequate safety measures and the fact that the regulatory authority was captive of the nuclear industry. The report of the Diet committee into the Fukushima accident[33] made the following comment about TEPCO’s attitude and its failure to respond to warnings:

“The reason why TEPCO overlooked the significant risk of a tsunami lies within its risk management mindset—in which the interpretation of issues was often stretched to suit its own agenda. In a sound risk management structure, the management considers and implements countermeasures for risk events that have an undeniable probability, even if details have yet to be scientifically confirmed. Rather than

considering the known facts and quickly implementing counter measures, TEPCO resorted to delaying tactics, such as presenting alternative scientific studies and lobbying" (p. 28).

The fact that the regulatory authority and the government succumbed to this lobbying is indicative of the industry's ability to distort the safety assessment process, not to mention the policy-making process. The nuclear industry downplayed the seriousness of the Three Mile Island accident and dismissed the lessons of Chernobyl as irrelevant to Japan, on the grounds that the reactor type was different and in the belief that such an accident could never happen in Japan. It continued to operate on the basis of the safety myth, despite repeated warnings in the form of accidents and critical scientific reports. Even after declaring the safety myth dead in the wake of the 1999 JCO criticality accident, the industry failed to adequately reflect the lessons in its practices and in its underlying mindset. Even now, it refuses to learn the lessons of Fukushima and is resurrecting the safety myth in its effort to restart nuclear reactors. To protect their financial position, Japan's electric power companies are pushing to restart their reactors, without first establishing adequate evacuation procedures,[34] ignoring the advice of scientists about the risks of volcanoes[35] and earthquakes, and before fully implementing the safety measures required under the new safety regulations[36] which are themselves inadequate.[37] The reason for this is that without the safety myth nuclear power plants cannot be operated.

In the wake of the Fukushima nuclear accident 160,000 people were evacuated. Four years later 120,000 evacuees[38] are still living in temporary accommodation, unable to return to their homes and suffering all manner of social and economic hardships. The Japanese government failed to notify some areas of the dangers and did not evacuate people in time.[39] For example, in the village of Iitate, which is 39km northwest of Fukushima Daiichi Nuclear Power Plant in the path of the main radiation plume, it took the government one month to order the villagers to evacuate from the highly contaminated area. As a result, many villagers remained and were exposed to high levels of radiation.[39]

Claims by nuclear proponents that there have been no deaths from radiation resulting from the Fukushima nuclear accident are disingenuous, bearing in mind the latency period for cancers and the inherent difficulty of finding epidemiological proof for causes of common medical conditions such as cancer (refer section 3:13 below). Based on a linear no-threshold model[40] Beyea et al (2013) suggest 1,000 future mortalities from radiation exposure as a reasonable mid-range estimate. To these must be added indirectly related deaths,[41] many of which were associated with the evacuation. There is an absurd claim from some of the more extreme nuclear proponents that fear mongering anti-nuclear activists were responsible for these deaths, but in reality full responsibility lies with those who perpetuated the nuclear safety myth, which prevented proper evacuation preparations being made, and who allowed the accident to happen in the first place.

CHERNOBYL – UKRAINE 26 April 1989 – ongoing
INES LEVEL 7: *"Major release of radioactive material with widespread health and environmental effects requiring implementation of planned and extended countermeasures"*

The Chernobyl accident occurred on 26 April 1986 when operators of the power plant ran a test on an electric control system of one of the reactors. As a consequence of explosions and graphite fires, a significant fraction of reactor core inventory was released. The accident happened due to a combination of both basic engineering deficiencies in the reactor and faulty actions of the operators. The safety systems had been switched off, and the reactor was being operated under improper, unstable conditions, which resulted in an uncontrollable power surge. This led to a cascade of events resulting in a series of explosions and fires that severely damaged the reactor building, completely destroyed the reactor, and caused the release of massive amounts of radioactive materials over a ten-day period across Europe.[42]

Twenty-eight reactor staff and emergency workers died from radiation and thermal burns within four months of the accident, and 19 more had died by the end of 2004. Some nuclear advocates like to pretend that these are the only people who died, with the stroke of a pen dismissing deaths that cannot be explicitly attributed to radiation exposure, even though it is well known from epidemiological studies that radiation induced cancers take many years to develop and cannot be distinguished from other cancers. In 2005 the Chernobyl Forum (made up of international organisations including the IAEA) initially estimated that 4,000 people would die as a result of exposure to radiation from Chernobyl, but it was roundly criticised for limiting the population considered and was forced to issue a revised report which included *"residents of other 'contaminated' areas"*. This effectively increased the number of estimated fatalities by 5,000 to 9,000, although it was left to a WHO report[43] to spell that out. This is still a much lower estimate than other surveys. Adequate health monitoring of evacuees has not being conducted so the full health impacts and the number of fatalities are inherently uncertain, but credible figures include 30,000 – 60,000 excess cancer deaths[44] and about 90,000.[45]

These figures ignore cancers whose progress was accelerated due to radiation, non-fatal radiation-induced illnesses, and the health impact of the disruption to lives caused by the evacuation. 116,000 people were evacuated and over 5 million people still live in the contaminated zone in Belarus, Russia and Ukraine. The radiation impacts were reduced to some extent by the relocation of residents, but the full socio-economic costs are enormous.

THREE MILE ISLAND USA – 28 March 1979
INES LEVEL 5 *"Accident with wider consequences"*

The Three Mile Island (TMI) accident was the worst in US commercial nuclear power plant history. A cooling malfunction caused a partial meltdown of the Number 2 reactor. Radioactive gases were released into the atmosphere and radioactive water was released into the local river, although the quantity of radioactivity released and the health effects are disputed (Wing et al 1997; Wing 2003).[46,47]

One important lesson from the TMI accident is that the nuclear industry does not learn the lessons of past accidents. Had the Japanese nuclear industry taken seriously the implications of TMI—namely that severe accidents can happen in Light Water Reactors—it would not have been so blasé about safety.

A common feature of all these nuclear accidents is the total inadequacy of emergency response preparation (Geist 2014).[48] As mentioned above, this failing is being repeated in Japan as it moves to restart its idled reactors. Given the difficult-to-access geography of the regions in which many Japanese nuclear power plants are located, if realistic and workable evacuation plans were required, the reactors would have to be permanently shut down. However, as before the accident, safety has been relegated to third priority, after profitability of the electric power companies and the policy preferences of the government.

3.10 If a facility to generate electricity from nuclear fuels was established in South Australia, what regulatory regime to address safety would need to be established? What are the best examples of those regimes? What can be drawn from them?

Regulators have failed to ensure the safe operation of nuclear energy worldwide, as illustrated by the list of nuclear accidents in section 3.9: Table 1. These are only some of the more serious accidents and the record is incomplete due to lack of public reporting and accountability.

Regulatory capture is a deep rooted problem, as discussed in section 3.9 in regard to Japan, but this is also true of other countries. For example, Princeton University's Frank von Hippel argues, *"Nuclear power is a textbook example of the problem of 'regulatory capture' — in which an industry gains control of an agency meant to regulate it."*[49]

A study by the Union of Concerned Scientists[50] gives a mixed assessment of the United States' Nuclear Regulatory Commission (NRC), labelling its record *"a tarnished gold standard"*. The report cites examples of NRC failings, including problems with transparency. For example, it says, *"The NRC has systematically withheld virtually all documents it received from nuclear plant owners about fire protection and emergency* *planning since October 2004"* and *"The NRC transformed what it touts as an open and transparent licensing process into secret negotiations between it and plant owners".*

The difficulty mentioned above of ensuring independence and transparency in nuclear regulation is another reason why South Australia should not embark on an expansion of its involvement in the nuclear fuel cycle.

3.11 How might a comparison of the emission of greenhouse gases from generating electricity in South Australia from nuclear fuels as opposed to other sources be quantified, assessed or modelled? What information, including that drawn from relevant operational experience should be used in that comparative assessment? What general considerations are relevant in conducting those assessments or developing these models?

A simple comparison of lifecycle greenhouse gas emissions from nuclear power with those from other energy sources fails to capture some crucial consequences of nuclear power programs. These consequences include displacing renewable energy, discouraging energy efficiency and entrenching a high energy production and consumption system. As discussed in section 3.7, nuclear energy is a direct competitor to renewable energy and an enemy of energy efficiency.[51]

This means that even if life cycle greenhouse gas emissions from nuclear energy are relatively low, the energy system as a whole will generate much higher emissions than a low consumption system emphasising demand-side measures and designed to reward the provision of quality energy services rather than energy supply per se. This low consumption system is the type of system that we should be aiming for if we want to solve the problem of global warming. Any assessment of greenhouse gas emissions of nuclear energy must be viewed in the context of the energy system that supports it, and from that perspective, nuclear energy is a loser.

That said, it is widely accepted that nuclear power results in lower carbon emissions than fossil fuel alternatives, although there is no scientific consensus on its full lifecycle emissions. Nevertheless, the lifecycle emissions for nuclear power generation are considerably higher than nuclear proponents often claim. Any attempts at scientifically and economically valid predictions and calculations need to fully include emissions generated in the mining, enrichment, decommissioning and waste management components of the life cycle, not just the electricity generation end. Lenzen finds in his review of various estimates that *"the greenhouse emissions from nuclear power vary from 10 to 130 grams of CO2 per kilowatt hour of power, with an average of 65 g per kWh – or roughly the same as wind power."*[52] Compare this with the results of Sovacool's (2008) survey.[53] He *"calculates that while the range of emissions for nuclear energy over the lifetime of a plant, reported from qualified studies examined, is from 1.4g of carbon dioxide equivalent per kWh (gCO2e/kWh) to 288gCO2e/kWh, the mean value is 66 g CO2e/kWh."*

However, it must be stressed that this is when total electricity generation is equal. But it is not equal, because systems dependent on nuclear energy will tend to promote higher energy consumption than distributed systems based on renewable energy and energy efficiency.

A further decisive argument against nuclear energy as a solution to climate change is the time it takes from planning to start-up of nuclear power plants. By the time a nuclear power plant was constructed in South Australia it would be too late.[54] By contrast, South Australia has renewable energy resources that can be exploited immediately with some technologies and relatively quickly with others.

Based on the above analysis, it is clear that nuclear energy cannot be a solution, or even a part of the solution to global warming. Rather, it is an obstacle to implementing effective solutions. Indeed, the Union of Concerned Scientists found that the nuclear industries subsidies set back *"more cost effective efforts to combat climate change".*[1]

3.12 What are the wastes (other than greenhouse gases) produced in generating electricity from nuclear and other fuels and technologies? What is the evidence of the impacts of those wastes on the community and the environment? Is there any accepted means by which those impacts can be compared? Have such assessments making those comparisons been undertaken, and if so, what are the results? Can those results be adapted so as to be relevant to an analysis of the generation of electricity in South Australia?

The nuclear fuel chain from extraction, milling, enrichment, power generation produces low, intermediate and high level nuclear waste which has serious and potentially fatal health, safety and environmental risks. Refer to our submission in response to Issues Paper 4.

3.13 What risks for health and safety would be created by establishing facilities for the generation of electricity from nuclear fuels? What needs to be done to ensure that risks do not exceed safe levels?

Based on the discussion of health and safety risks in section 3.9, and on the discussion below about the medical effects of ionising radiation, in order to ensure the health and safety of Australians, no nuclear reactors should be built in Australia.

It is scientifically proven that exposure to high doses of radiation can cause serious harm or death. Animal studies have shown that treatment of an animal with radioactive materials can cause cancer and experience from exposure to nuclear weapons and radiation accidents shows that a 5 sievert dose is usually fatal for humans. Studies have also calculated that the lifetime risk of dying of cancer from a single radiation dose of 0.1 sievert is 0.8% and that the risk increases by 0.8% for each additional 0.1 sievert increment.[55] There is dispute about the impact of radiation doses below 0.1 sievert, but the mainstream scientific position supports the linear no-threshold model for cancer. The executive summary of the comprehensive BEIR VII report[56] states as follows:

“The Committee judged that the linear no-threshold model (LNT) provided the most reasonable description of the relation between low dose exposure to ionizing radiation and the incidence of solid cancers that are induced by ionizing radiation” (p. 6)

In regard to leukaemia, an authoritative recent report[57] based on an international cohort of over 300,000 radiation-monitored workers representing over 8 million person-years, concludes that their study *“provides strong evidence of positive associations between protracted low-dose radiation exposure and leukaemia”* (p. 276).

Despite this evidence, nuclear advocates have gone out of their way to trivialise the risks of exposure to low levels of radiation. In response to the Fukushima disaster, US advocacy group, Physicians for Social Responsiblity, criticised press reports that implied there is a safe threshold for ionizing radiation exposure:

"As the crisis in Japan goes on, there are an increasing number of sources reporting that 100 mSv (millisieverts) is the lowest dose at which a person is at risk for cancer. Established research disproves this claim. According to the National Academy of Sciences, there are no safe doses of radiation. Decades of research show clearly that any dose of radiation increases an individual's risk for the development of cancer."[58]

Associate Professor Tilman Ruff of University of Melbourne's Nossal Institute for Global Health and International Physicians for the Prevention of Nuclear War says there may be a threshold for some effects of radiation, but not for cancer. *"There is unfortunately a continuing tirade of statements by self-interested parties and some official agencies ... implying a threshold for radiation exposure below which there are no adverse consequences*."[58]

The unscientific nature of the claims of these “self-interested parties” is clear when one considers two key principles: the principle that lack of proof of harm is not proof of no harm, and the precautionary principle. Where a significant body of research suggests that low doses of radiation are harmful, in view of the inherent difficulty of finding epidemiological proof for causes of common medical conditions, it is disingenuous to demand absolute proof before taking protective action. Bearing in mind the latency period for cancers and the two above mentioned principles, claims by nuclear proponents that there have been no deaths from radiation resulting from the Fukushima nuclear accident are further evidence of the unscientific self-interested nature of the industry. It is not that nuclear proponents are not aware of these principles. It is rather that their purpose is propaganda, instead of science and public health protection.

In this regard, the permitted radiation dose for workers involved in radioactive industries has steadily decreased over time as more safety information has become available. The permitted dose was set at 500 millisieverts per year in 1934, reduced to 150 mSv in 1950, reduced again to 50 mSv in 1956, and reduced again to 20 mSv (averaged over five years) in 1991. The current internationally recognised limit for members of the public is just 1 mSv. However the response of the Japanese government to the Fukushima nuclear accident has been to deny the science and relax the standards, rather than to take responsibility. This has been done without the consent of the public in order to limit its own liability and the liability of Tokyo Electric Power Company.

3.14 What safeguards issues are created by the establishment of a facility for the generation of electricity from nuclear fuels? Can those implications be addressed adequately? If so, by what means?

The implications for nuclear proliferation depend on the type of reactors chosen. Reactors which use plutonium or highly enriched uranium (HEU) fuel create greater risks than reactors that use low enriched or natural uranium fuel. Separated plutonium and HEU can potentially be diverted to direct use in nuclear weapons. Irradiated plutonium in spent nuclear fuel from low enriched uranium (LEU) fuelled light water reactors is considered to be self-protecting against theft due to the high levels of radiation, but this does not mean state actors cannot reprocess the spent fuel and separate out the plutonium, nor does it mean that the IAEA will be able to adequately resource the safeguards regime, and technical limitations also remain. The challenge is arguably greater for pressurised heavy water reactors (PHWR) due to such factors as continuous refueling.[59]

Any fuel cycle involving recycling of plutonium creates greater risks of diversion. According to the International Panel on Fissile Materials:

'It was only at the end of the Bush-Cheney Administration that a systematic proliferation assessment of pyroprocessing by six U.S. national laboratories, including Argonne, was launched. In 2009, a summary report was published that assessed pyroprocessing and two other proposed reprocessing technologies that do not produce pure separated plutonium. It found "only a modest improvement in reducing proliferation risk over existing PUREX technologies and these modest improvements apply primarily for nonstate actors"' (p. 76).[60]

Thorium fuels are touted by many as proliferation resistant, but their proliferation resistant qualities are overstated. Thorium-232 must first be bombarded with neutrons to produce uranium-233, which can be and has been used to make nuclear weapons.[61] The protection afforded by the gamma radiating by-product uranium-232 is by no means insurmountable.[62] Furthermore, the neutrons to start the reaction would probably come from plutonium-based fast reactors. This is the concept on which India's thorium program is based.[63]

IAEA safeguards are only effective when the state cooperates. If the state is cooperative, material accounting is not so challenging when it only involves counting spent fuel assemblies, but if spent fuel is reprocessed (or pyroprocessed) accounting becomes difficult. It is not possible to guarantee that the IAEA's objective of *"timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons"*[64] will be met.[65]

Probably most Australians would be surprised if doubts were raised about Australia's credibility on nuclear nonproliferation. While we do not believe that Australia currently has any intention of acquiring nuclear weapons, it is worth remembering that up until the early 1970s Australia considered doing just that.[66]

However, probably a greater concern at this time is the implications of an Australian nuclear energy program for regional nuclear proliferation. An expansion by Australia into nuclear energy would be noted by our neighbours, some of whom might feel challenged to follow suit. As Australian military strategists are at pains to point out, Australia considers not only the military intentions but also the military capabilities of other countries, so naturally those same countries would view Australia's nuclear energy program in a similar light. And even if Australia's program was benign, other countries' programs might not be. It is important to remember that all examples of nuclear proliferation were conducted under the cover of a 'peaceful' nuclear energy program without consulting the public.

Another risk of installing a nuclear power station that is usually downplayed is that it would create a target for terrorism. It would also involve the storage and creation of material suitable for dirty bombs. Perhaps even greater than the risk of attack by outsiders is the risk of sabotage or other security breaches by insiders. Also, there are countries and terrorist groups who resort to illegal activities to obtain nuclear material for violent purposes. The International Atomic Energy Agency (IAEA) has received information that shows *"a persistent problem with the illicit trafficking in nuclear and other radioactive materials, thefts, losses and other unauthorized activities".*[67]

The International Atomic Energy Agency's Incident and Nuclear Trafficking Database notes there have been 1,266 incidents reported by 99 countries over the last 12 years, including 18 incidents involving highly enriched uranium or plutonium trafficking.[68]

The fact is that nuclear power generation is inextricably linked to nuclear weapons proliferation and the best way Australia can contribute to preventing proliferation is by extricating itself from the nuclear industry (refer to our submission in response to Issues Paper 2).

3.15 What impact might the establishment of a facility to generate electricity from nuclear fuels have on the electricity market and existing generation sources? What is the evidence from other existing markets internationally in which nuclear energy is generated? Would it complement other sources and in what circumstances? What sources might it be a substitute for, and in what circumstances?

Refer to sections 3.2 and 3.7 for discussion of the inappropriateness of nuclear energy for the electricity system in South Australia and the National Energy Market and also the devastating impact introducing nuclear power would have on renewable energy and energy efficiency. Renewable energy is growing rapidly globally, while nuclear energy is stagnant,[69] but the nuclear industry is fighting to block the shift to an energy system that favours renewable energy and energy efficiency.[70]

Nuclear energy will not complement variable renewable energy sources such as wind and photovoltaics. Rather it will squeeze them out, as it has done in Japan and France, and to varying degrees in other countries. Some might wonder about China, where renewable energy and nuclear energy are growing simultaneously, but that is because China's economy has been growing rapidly, so the Chinese example is not applicable to South Australia.

NUCLEAR FINANCIAL SUBSIDIES

Nuclear energy also directly competes with renewable energy for investment dollars. Pro-nuclear lobbyists around the world are pushing hard for an expansion of their industry to be paid for with taxpayer subsidies at the expense of renewable energy. Nuclear power is not feasible without huge subsidies (refer to section 3.6, 3.16 and Appendix 1). One recent example of nuclear subsidies is the European Commission's approval of a 'contract for difference' arrangement for the Hinkley Point C nuclear power station in the UK. The legality of this subsidy is being challenged by the Government of Austria among others (refer section 3.6). Currently in Australia renewable energy also receives a subsidy, but much less than the nuclear industry would need. Technology development and economies of scale are bringing down the price of renewables, while the price of building nuclear reactors is steadily increasing.[71]

RENEWABLE ENERGY

The Renewable Energy Policy Network (REN21) produced a report in 2015 about the global status of renewable energy. REN21 is an international non-profit association and is based at the United Nations Environment Programme (UNEP) in Paris, France.[72] The "*Renewables 2015 Global Status Report*," concluded that 164 countries used solar, wind and other technologies (including large hydro-electric schemes) which added another 135 Gigawatts last year to bring the world's total installed renewable energy power capacity to 1,712 GW. This is an 8.5 percent increase from 2013, and more than double the 800 GW of capacity recorded in 2004. One GW can power between 750,000 and one million typical U.S. homes.

The REN21 authors say the renewables sector's growth could be even greater were it not for more than **US$550 billion paid out in annual subsidies for fossil fuels and nuclear energy**. They say the **subsidies keep the prices for energy from these fuels artificially low**, encouraging wasteful use and **hindering competition.** Christine Lins, executive secretary of REN21 says: *"Creating a level playing field would strengthen the development and use of energy efficiency and renewable energy technologies. Removing fossil fuel and hidden nuclear subsidies globally would make it evident that renewables are the cheapest energy option."*[72]

3.16 How might a comparison of the unit costs in generating electricity in South Australia from nuclear fuels as opposed to other sources be quantified, assessed or modelled? What information, including that drawn from relevant operational experience, should be used in that comparative assessment? What general considerations should be borne in mind in conducting those assessments or models?

Any calculation or discussion of the unit cost of electricity generated from nuclear sources must include the back end costs of decommissioning and management and disposal of radioactive waste. Only eleven nuclear power plants have been decommissioned[73] and no country has disposed of its high level nuclear waste, so these costs can only be estimates, but even before disposal has begun estimates have been escalating. For example, the estimated cost of a repository for high level waste in France has escalated from Eur13.5-16.5 billion in 2005 to Eur35 billion in 2013.[74,75] Given the time frames involved for disposal of nuclear waste and considering the inaccuracy of cost estimates for other parts of the nuclear fuel cycle (see below), one would expect costs to escalate further.

Cost estimates should also include some form of fund to cover the cost of potential accidents. However there are serious methodological difficulties in estimating these costs. Historically the nuclear industry has minimised its responsibility for these costs in various ways, including by under-estimating the potential cost of accidents, by underestimating the frequency of accidents, and through limits on liability. As a result, the taxpayer will end up carrying the burden.

In regard to the potential cost of accidents, Oshima et al[76] estimate the cost of the Fukushima accident at $US105 billion, while Wheatley et al (2015) estimate $US166 billion,[77] but it must be remembered that the accident could easily have been much worse. Had most of the radioactivity been deposited on land rather than out to sea, or had the Reactor 4 spent fuel pool boiled dry (a situation that was averted only by an extraordinary stroke of luck)[78] the catastrophe would have been many times worse than it actually was. As Chairman of the Japan Atomic Energy Commission at the time, Shunsuke Kondo provided advice to the government that in the latter case, based on the Chernobyl evacuation protocols, a zone of 170 km radius might have to be forcibly evacuated and voluntary evacuation of a 250 km radius might have to be permitted.[79] That area includes a large part of Tokyo. As if that was not bad enough, when the Royal Commissioner visited Japan no doubt he heard from the former Mayor of Tokai how fortunate the Tokai-2 reactor was to avoid the same fate as Fukushima Daiichi. Clearly estimates based on the assumption that the Fukushima nuclear accident was a worst case scenario are wide of the mark.

In regard to estimating the frequency of accidents, bottom-up probabilistic risk assessment is the traditional method that has been used, but the frequency estimated in this way has been far wide of actual frequency. Wheatley et all suggest that it would be better to use theoretical models from risk theory. Based on data from past accidents, they estimate that *"there is a 50% chance that (i) a Fukushima event (or larger) occurs in the next 50 years, (ii) a Chernobyl event (or larger) occurs in the next 27 years and (iii) a TMI event (or larger) occurs in the next 10 years."*[80] (They estimate that the Fukushima accident was the most costly accident in history. There is sufficient uncertainty about the cost of the Fukushima and the Chernobyl accidents that we do not necessarily assume the Fukushima accident was more costly than the Chernobyl accident. See, for example, the "hundreds of billions of dollars" ball-park figure in the report of the Chernobyl Forum (2005).[42])

The third way in which the nuclear industry avoids paying the full costs of nuclear power is through limits on its liability. Given that the full potential costs of nuclear accidents are uninsurable, industry either must obtain a limit on its liability or bet the company when building a nuclear power plant. In any event, they will not be able to pay the full costs of a severe nuclear accident, so the public will inevitably end up bearing the burden. In the case of the Fukushima accident there was no limit on liability, but the government decided that it would not let TEPCO default, so in fact taxpayers are carrying most of the burden. By contrast, the United States established a law which explicitly limits liability and requires nuclear operators to take out insurance to cover up to that limit. The US Price Anderson Act[81] began in 1957 and was last re-signed in 2005 for another 20 years. Critics of the Price-Anderson Act point out that it acts as a direct subsidy for nuclear power, a subsidy which is not available to other sources of power such as renewables.

The Price-Anderson Nuclear Industries Indemnity Act (commonly called the Price-Anderson Act) is a United States federal law, first passed in 1957 and since renewed several times, which governs liability-related issues for all non-military nuclear facilities constructed in the United States before 2026. The main purpose of the Act is to partially indemnify the nuclear industry against liability claims arising from nuclear incidents while still ensuring compensation coverage for the general public. The Act establishes a no fault insurance-type system in which the first approximately $US12.6 billion (as of 2011) is industry-funded as described in the Act. Any claims above the $US12.6 billion would be covered by a Congressional mandate to retroactively increase nuclear utility liability or would be covered by the federal government. At the time of the Act's passing, it was considered necessary as an incentive for the private production of nuclear power — this was because electric utilities viewed the available liability coverage (only $60 million) as inadequate.

The above costs are on top of the costs of construction and operation of nuclear power plants. The few nuclear power plants currently under construction in western countries are all years behind schedule and way over budget. The current predicted start up date for Finland's 1,660-MW Olkiluoto-3 EPR is late 2018 after originally being scheduled to start in April 2009.[82] It was originally meant to cost Eur3.2 billion, but it is now estimated that it will end up costing Eur8.5 billion.[83] Of course, that still leaves plenty of time for more delays and price escalations. France's Flamanville-3 EPR is similarly behind schedule and over budget, but there is now a cloud over whether it will ever be safe to operate due to problems with the manufacture of its pressure vessel.[84] Areva, the company that is constructing these plants, is facing bankruptcy. The AP1000s being constructed in the US are also behind schedule and over budget. The first new unit at the Vogtle nuclear power station is now scheduled to enter commercial operation in mid-2019, after an original target date of April 2016.[85]

NEXT GENERATION NUCLEAR TECHNOLOGIES

In view of these massive cost over-runs and extreme delays in existing construction projects, as well as historical failures which Forbes magazine described as the "largest managerial disaster in business history",[86] cost estimates for next generation reactor technologies which have never been commercially constructed carry little credibility. No economic model can meaningfully address this unreliability. Nuclear proponents speak as if SMRs and Gen 4 reactors were ready to roll, but, as discussed in section 3.2, this is far from the truth. There is, therefore, no sound basis for making cost estimates or predicting when new technologies might become commercially viable.

COMPARISON WITH RENEWABLES

While the costs of nuclear energy continue to rise, the costs of renewable energy continue to fall.[87] Furthermore, given that renewable energy is installed in smaller increments and comes on line much quicker than nuclear power plants, the investment risk is much less for renewable energy than for nuclear energy.

We note that it is important to ensure that when making cost comparisons, the correct basis is used. For example, while for large scale renewable plants feeding into the NEM the wholesale price of electricity is an appropriate basis for comparison, for rooftop solar, depending on the household's consumption patterns, it may be better to use the retail price, because at least some of the electricity generated displaces electricity that would otherwise have been purchased at retail prices. According to Diesendorf (2015), "Rooftop solar PV is now economically competitive with retail prices of grid electricity in most of Australia."[88]

For a more detailed comparison of the economic viability of renewables versus nuclear, we refer the Royal Commission to the work of Mark Diesendorf.[26,27]

3.17 Would the establishment of such facilities give rise to impacts on other sectors of the economy? How should they be estimated and using what information? Have such impacts been demonstrated in other economies similar to Australia?

As discussed above, the development of a nuclear power industry would impact extremely negatively on the expansion of our renewable energy and energy efficiency industries, as it is in direct competition with these industries and because it dictates a different type of energy system from that in which renewable energy and energy efficiency can thrive.

Nuclear power plants operating without incident would be expected to negatively effect fisheries, as has occurred in other places where nuclear power plants have been established.[89] However, if there was an accident, even if only a small amount of radioactivity was released, the reputational damage could be substantial to not only fisheries, but also other industries including agriculture and tourism.

If there was a major accident at a South Australian nuclear power station, or during transport of nuclear materials, the impact on the local economy could be devastating. The financial and human impact would depend on the location of the accident, but if, for example, a major accident occurred at a nuclear power station built at Port Adelaide, it is likely that the whole of Adelaide would need to be evacuated and possibly even abandoned completely. For the benefit of those who have difficulty empathising with the human suffering that this would represent and only understand dollars, an economy worth $70 billion[90] would be lost. The financial cost would be accordingly less if the reactor was located in a less populated area, but the impact on the people living in the vicinity would be just as great.

The Fukushima and Chernobyl accidents provide ample proof of the human tragedy (and the economic loss, for those who only count dollars) that results from severe nuclear accidents. The Fukushima accident was disastrous for the economy of the area surrounding the power plant, as described in sections 3.6 and 3.16. Agriculture, fishing, tourism and other industries in Fukushima Prefecture were devastated and even though the national and prefectural governments reassure the public of the safety of the produce, people are still reluctant to buy. Exports suffer even more, as evidenced by the fact that four years after the accident foreign governments continue to restrict imports of Japanese agricultural produce, especially from the Tohoku region.[91,92]

The Chernobyl accident and the measures taken to deal with its consequences have cost the Soviet Union—and later Belarus, the Russian Federation and Ukraine—in the order of hundreds of billions of dollars.[42] Economic losses were also incurred by other European countries, including Scandinavian countries.[93] Direct costs include direct damage caused by the accident, expenditures related to sealing off the reactor, treating the Exclusion Zone and other affected areas, resettling people, providing health care and social protection for those affected, monitoring radiation, and disposing of radioactive waste. Indirect costs include restrictions in the use of agricultural land and forests, the closure of industrial and agricultural facilities, and increased energy costs resulting from the closure of the Chernobyl plant.

CONCLUSION

Given that South Australia is second to none in renewable energy resources, we wonder why anyone would contemplate committing us to a high risk technology in decline, when we can be a leader in technologies of the future. In view of the above discussion, we believe the only reasonable response this Royal Commission can make is to recommend that the government reject the nuclear option and embrace the energy transformation that is taking place around the world by committing itself to the realisation of a 100% renewable energy future.

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APPENDIX 1

"Nuclear Power: Still Not Viable Without Subsidies"

Doug Koplow,
Earth Track,
Union of Concerned Scientists
February 2011